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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Navy Department

FREE-SPINNING TUNNEL TESTS OF A $\frac{1}{25}$-SCALE MODEL OF THE NORTH AMERICAN XFJ-1 AIRPLANE

TED NO. NACA 2400

By

Theodore Berman

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Langley Field, Va.

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[redacted]

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

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SUMMARY

An investigation has been conducted in the Langley free-spinning tunnel to determine the spin and recovery characteristics of a $\frac{1}{25}$-scale model of the North American XFJ-1 airplane. The erect spin and recovery characteristics were determined for the normal and long-range loadings. The investigation also included dive brakes, spin-recovery parachutes, pilot-escape tests, and rudder-force measurements.

The recovery characteristics of the model were satisfactory for all conditions tested. In the normal loading, rapid recoveries were obtained by rudder reversal alone but for the long-range loading it was necessary to move the stick forward in conjunction with rudder reversal to obtain satisfactory recoveries. An 8.3-foot tail parachute with a drag coefficient of 0.67 or a 4.2-foot wing tip parachute having a drag coefficient of 0.74 was found satisfactory as an emergency spin-recovery device from demonstration spins. It was indicated that in an emergency, the pilot should attempt to escape from the outboard side of the spinning airplane. The rudder forces in the spin appeared well within the capabilities of the pilot.

INTRODUCTION

In accordance with the request of the Bureau of Aeronautics, Navy Department, an investigation has been conducted in the Langley 20-foot free-spinning tunnel to determine the spin and recovery characteristics of a $\frac{1}{25}$-scale model of the North American XFJ-1 airplane. The XFJ-1 is a low-wing, single-place, jet-propelled fighter.

The spin and recovery characteristics were determined for erect spins in the normal and long-range loadings. The effect of extending the dive brakes was also investigated. Tests were performed to determine the optimum size wing-tip and tail parachutes that should be used as emergency-recovery devices. Tests were also performed to determine the best method for the pilot to leave the airplane in an emergency, and to determine the rudder force required for recovery from the spin.

SYMBOLS

b	wing span, feet
m	mass of airplane, slugs
S	wing area, square feet
$\bar{c}$	mean aerodynamic chord, feet
$x/\bar{c}$	ratio of distance of center of gravity rearward of leading edge of mean aerodynamic chord to mean aerodynamic chord
$z/\bar{c}$	ratio of distance between center of gravity and thrust line to mean aerodynamic chord (positive when center of gravity is below thrust line)
I_X, I_Y, I_Z	moments of inertia about X, Y, and Z body axes, respectively, slug-feet^2
$\frac{I_X - I_Y}{mb^2}$	inertia yawing-moment parameter
$\frac{I_Y - I_Z}{mb^2}$	inertia rolling-moment parameter
$\frac{I_Z - I_X}{mb^2}$	inertia pitching-moment parameter
ρ	air density, slug per cubic foot

$\mu = \frac{m}{\rho S b}$ relative density of airplane

α angle between thrust line and vertical (approximately equal to absolute value of angle of attack at plane of symmetry), degrees

ϕ angle between span axis and horizontal, degrees

V full-scale true rate of descent, feet per second

Ω full-scale angular velocity about spin axis, revolutions per second

σ helix angle, angle between flight path and vertical, degrees (For this model, the average absolute value of the helix angle was approximately 3°.)

β approximate angle of sideslip at center of gravity, degrees (Sideslip is inward when inner wing is down by an amount greater then the helix angle.)

APPARATUS AND METHODS

Model

The $\frac{1}{25}$-scale model of the North American XFJ-1 airplane used for the tests was furnished by the Bureau of Aeronautics, Navy Department, and was prepared for testing and checked for dimensional accuracy by Langley. Dimensional characteristics of the airplane are given in table I. A three-view drawing of the model as tested in the normal loading is given as figure 1. Photographs of the model in the normal and long-range loadings are shown in figure 2. Figure 3 shows a sketch of the model with the dive brakes extended.

The model and model external fuel tanks were ballasted by means of lead weights to obtain dynamic similarity to the corresponding airplane and full-scale fuel tanks at an altitude of 15,000 feet (ρ = 0.001496 slug/cu ft). The weights, moments of inertia, and center-of-gravity locations were obtained from data furnished by North American Aviation, Incorporated. A remote-control mechanism was installed to actuate the controls or open the parachute for recovery tests, or to release the pilot for pilot-escape tests.

A $\frac{1}{25}$-scale model of a 6-foot man used for the pilot-escape tests was built by Langley and was dynamically ballasted by means of lead weight to represent a pilot with a parachute (200 lb) at an altitude of 15,000 feet.

Wind Tunnel and Testing Technique

The tests were performed in the Langley 20-foot free-spinning tunnel, the operation of which, in general, is similar to that described in reference 1 for the Langley 15-foot free-spinning tunnel. With the controls set in position, the model is launched by hand into the vertically rising air stream. After a number of turns in the established spin, a recovery attempt is made by moving one or more controls by means of the remote-control mechanism. After recovery, the model dives into the safety net. The spin data obtained from these tests are then converted to corresponding full-scale values by methods also described in reference 1. The model is shown spinning in the Langley 20-foot free-spinning tunnel in figure 4.

In accordance with standard spin-tunnel procedure, tests were performed to determine the spin and recovery characteristics of the model for the normal spinning control configuration (elevator full up, ailerons neutral, and rudder full with the spin) and for various other aileron-elevator combinations including neutral and maximum settings of the control surfaces for various model conditions. Recovery was generally attempted by rapid full rudder reversal from full with to full against the spin. Tests were also performed to evaluate the possible adverse effects of small deviations from the normal control configuration for spinning. For these tests, the elevator was set at either two-thirds of its full-up deflection, or full up, while the ailerons were one-third of full deflection in the direction conducive to the slower recoveries (with the spin for the XFJ-1 model). Recoveries from this spin were attempted by either rapidly reversing the rudder from full with to two-thirds against the spin or by simultaneous movement of the rudder to two-thirds against the spin and of the elevator to one-third down. This particular control configuration and manipulation is referred to as the "criterion spin." Turns for recovery were measured from the time the controls were moved, or the parachute was opened, to the time the spin rotation ceased. Spin-tunnel experience has resulted in the requirement that for a model to be considered as satisfactory as regards spin recovery, the model must recover from the criterion spin in $2\frac{1}{4}$ turns or less.

For the spins which had a rate of descent in excess of that which could be readily attained in the tunnel, the rate of descent was recorded as greater than the velocity at the time the model hit the safety net, as > 300. For recovery attempts in which the model struck the safety net before recovery could be effected because of the wandering motion of the model, or because of an unusually high rate of descent, the number of turns from the time the controls were moved to the time the model struck the safety net was recorded. This number indicates that the model required more turns to recover from the spin than shown, for example > 3. A > 3-turn recovery, however, does not necessarily indicate an improvement when compared with a > 7-turn recovery. The symbol ∞ is used on the charts to indicate that the model would not recover. Some recovery attempts were made shortly after the model had been launched into the tunnel and before it had completely steepened to its final attitude. Inasmuch as recoveries so obtained are somewhat slower than recoveries obtained after the model has attained its final steeper spin attitude, the results are considered conservative. Such recovery data are noted on the charts as "recovery attempted before model reached final steep attitude." When the model recovered without control movement when launched in a spinning attitude with the controls set for the spin, the result was recorded as "no spin."

The testing technique for determining the optimum size of, and towline length for, spin-recovery parachutes is described in reference 2. For the present tests, the model was launched into the tunnel with the rudder set full with the spin. The control settings of the steady spin were maintained during the recovery attempt. For the tail-parachute tests, the packed parachute and towline were mounted near the rear of the fuselage below the horizontal tail in such a manner as to have no effect on the spin characteristics of the model until opened. The testing technique for the wing-tip parachute was essentially the same as that for the tail parachute except that the packed parachute and towline were mounted on the upper surface of the outer wing tip (left wing tip in a right spin). When the parachute was attached to the wing tip, the towline was so adjusted that the parachute would just miss the stabilizer when fully extended. It is recommended for full-scale wing parachute installations that the parachutes be packed within the airplane structure. All parachutes should be provided with positive means for ejection into the air stream. The drag coefficient for each parachute used was measured at the time of the tests and the values are indicated herein.

For the tests to determine from which side of the spinning airplane the pilot should escape in an emergency, the dummy pilot was released from the inboard side (right side in a right spin) and from the outboard side of the fuselage at the cockpit by actuating the remote-control mechanism when the model was in a typical flat spin and when it was in a typical steep spin.

PRECISION

The spin results presented herein are believed to be the true values given by the model within the following limits:

α, degrees	± 1
ϕ, degrees	± 1
V, percent	± 5
Ω, percent	± 2
Turns for recovery	$\pm\frac{1}{4}$ turn when obtained from motion picture records $\pm\frac{1}{2}$ turn when obtained by visual estimate

The preceeding limits may have been exceeded for certain spins in which it was difficult to control the model in the tunnel because of the high rate of descent or because of the wandering or oscillatory nature of the spin.

Comparison between model and airplane spin results (references 1 and 3) indicates that spin-tunnel results are not always in complete agreement with airplane spin results. In general, the models spun at a somewhat smaller angle of attack, at a somewhat higher rate of descent, and with 5° to 10° more outward sideslip than did the airplanes. The comparison made in reference 3 for 20 airplanes showed that 80 percent of the models predicted satisfactorily the corresponding airplane recovery characteristics and that 10 percent overestimated and 10 percent underestimated the corresponding airplane recovery characteristics.

Little can be stated about the precision of the pilot-escape tests as no comparable airplane data are available. It is felt, however, that if the dummy pilot is observed to clear all parts of the model by a large margin after being released, the pilot may escape from the corresponding airplane.

Because it is considered impracticable to ballast the model exactly and because of inadvertant damage to the model during the tests, the measured weight and mass distribution of the XFJ-1 model varied from the true scaled-down values within the following limits:

Weight, percent		2 low to 1 low
Center-of-gravity location, percent $\bar{c}$		1 forward to 0
Moments of inertia	I_X, percent	3 high to 2 high
	I_Y, percent	1 low to 1 high
	I_Z, percent	4 low to 2 low

The limits of accuracy of the measurements of the mass characteristics were as follows:

Weight, percent	±1
Center-of-gravity location, percent $\bar{c}$	±1
Moments of inertia, percent	±5

Controls were set with an accuracy of ±1°.

TEST CONDITIONS

Tests were performed for the model conditions listed on table II. The mass characteristics and mass parameters possible on the airplane and tested on the model are listed on table III. The mass-distribution parameters for the loadings of the XFJ-1 airplane and for the loadings tested on the model are plotted on figure 5. As discussed in reference 4, figure 5 can be used in predicting the relative effectiveness of the controls on the recovery characteristics of the model.

Several airplane loading conditions were considered in the preparation of the test program for the model. Spin tests were performed on the model, however, only for the normal and long range loadings as it was felt that results for these conditions would cover the possible range of recovery characteristics.

The tail-damping power factor, which was 708×10^{-6}, was computed by methods described in reference 5.

The normal maximum control deflections used in the current tests were:

Rudder, degrees	25 right, 25 left
Elevator, degrees	30 up, 10 down
Ailerons, degrees	30 up, 20 down
Dive brakes, degrees	90 up and down

The intermediate control deflections used were:

Rudder, two-thirds deflected, degrees	$16\frac{2}{3}$
Elevator, two-thirds up, degrees	20
Elevator, one-third down, degrees	$3\frac{1}{3}$
Ailerons, one-third deflected, degrees	10 up, $7\frac{4}{5}$ down

RESULTS AND DISCUSSION

The results of the tests are presented on charts 1 through 3 and table IV. The model data are presented in terms of full-scale values for the airplane at an altitude of 15,000 feet. Right and left spins of the model were generally similar. All data are arbitrarily presented in terms of right spins and may be considered representative of the airplane spinning in either direction.

Normal Loading

Clean condition.- The results of erect spin tests of the model are presented on chart 1. All spins obtained were steep with a high rate of descent. Recovery by full rapid rudder reversal was satisfactory for all spins.

The results indicated that after recovery from some spins, the model tended to spin in the opposite direction when full rudder reversal was used. Test results with rudder neutralization indicated satisfactory recoveries with a diminished tendency for the model to enter a spin in the opposite direction. It is therefore recommended that extreme care be exercised by the pilot to avoid entering a spin in the opposite direction when recovery is attempted.

Dive brakes extended.- Chart 2 gives the test results obtained with the model in the normal loading with the dive brakes fully extended. Extending the dive brakes had little effect on the spin and recovery characteristics of the model. All spins obtained were steep with high rates of descent. Aileron-against spins were slightly steeper and aileron-with spins were as steep but had somewhat slower recoveries than corresponding normal loading, clean condition spins.

Long-Range Loading

Results of tests made with external fuel tanks installed on the wing tips are given on chart 3. Aileron-with settings were very adversely affected by this loading change, and recovery, based on the criterion spin, was not considered satisfactory by rudder reversal alone; satisfactory recovery was obtained, however, when the elevator was moved down in conjunction with rudder reversal.

Spin-Recovery Parachute Tests

Results of spin-recovery parachute tests are presented in table IV. For these tests, as previously mentioned recoveries were attempted by opening the parachute without moving the controls. The model parachutes were of the flat circular type, made of silk, and had drag coefficients as indicated in table IV. If parachutes with lower drag coefficients are used on the airplane the parachute diameters must be correspondingly larger.

Tail parachute tests.- Test results with tail parachutes show that an 8.3-foot parachute with a drag coefficient of 0.67 and with a 25-foot towline was the minimum size that would cause satisfactory recoveries from spins by parachute action alone.

Wing-tip parachute tests.- Test results obtained with wing-tip parachutes indicate that a 4.2-foot parachute having a drag coefficient of 0.74 and with an 11.6-foot towline attached to the outer wing tip (left wing in a right spin) would effect satisfactory recoveries.

Pilot-Escape Tests

Brief tests were made to determine from which side of the spinning airplane the pilot should attempt an emergency jump if in an uncontrollable spin. When the model pilot was released from the inboard side of the fuselage in a steep spin, it was observed that it sometimes struck the tail surfaces; when released from the outboard side, it appeared to clear the tail surfaces by a small margin. Inasmuch as model results indicated that recovery from the steep spin would be readily obtained, this result was not considered serious. Tests were also made from a moderately flat spin obtained with wing tanks installed and it was noted that the model pilot cleared the model by a fairly large margin when released from the outboard side. From the results obtained, it appears that if for some reason an uncontrollable spin is obtained, the pilot should jump from the outboard side.

Inverted Spins

Although not specifically tested, some inverted spins were obtained in the course of the test program after recoveries from erect spins. Based on the results presented in reference 6 and spin-tunnel experience gained with other models, it is felt that recovery from all inverted spins obtained with this model would have been satisfactory by full rudder reversal followed by stick neutralization, laterally and longitudinally.

Landing Condition

The landing condition was not tested on the model inasmuch as the current Navy specifications require airplanes to demonstrate satisfactory recoveries in the landing condition from only 1-turn spins. At the end of 1-turn, the airplane will probably still be in an incipient spin from which recoveries are more readily obtained than from fully developed spins such as are obtained with models in the free-spinning tunnel. An analysis of the results of full-scale and model tests of many airplanes to determine the effect of flaps and landing gear indicates that the XFJ-1 airplane will probably recover satisfactorily from a 1-turn spin in the landing condition but that recoveries from fully developed spins in the landing condition may be unsatisfactory. It is recommended, therefore, that the flaps be neutralized and recovery be attempted immediately upon entering a spin in the landing condition in order to insure that transition from the incipient to the fully developed spin does not take place.

Control Forces

The discussion of the results so far has been based on control effectiveness alone without regard to the forces required to move the controls. For all tests, as previously mentioned, sufficient force was applied to the controls to move them fully and rapidly. Sufficient force must be applied to the airplane controls to move them in a similar manner in order for model and airplane results to be comparable.

A few tests were performed with the model in the normal loading in which the forces applied to the rudder in order to effect a recovery were measured. The results indicated that the full-scale rudder pedal force would be approximately 100 pounds which, as indicated in reference 7, is within the capabilities of the pilot. Because of lack of detail in the balance of the model, of inertia mass-balance effects, and of scale effects, these results are only qualitative indications of the actual forces that may be experienced.

CONCLUSIONS

Based on the results of spin tests of a $\frac{1}{25}$-scale model of the North American XFJ-1 airplane, the following conclusions regarding the spin and recovery characteristics of the airplane at a spin altitude of 15,000 feet were obtained:

1. The spin and recovery characteristics of the airplane will be satisfactory for all loading conditions when the recommended recovery technique is used. For recovery, it is recommended that the stick be held full back and laterally neutral, the rudder should then be fully and rapidly reversed; after rudder reversal, the stick should be briskly moved forward of neutral maintaining it laterally neutral. In the event that the airplane enters a spin in the opposite direction immediately upon recovery from the initial spin, recovery should then be attempted by neutralizing the rudder.

2. A 4.2-foot parachute on the outer wing tip will be effective for emergency recoveries from spins as will also an 8.3-foot tail parachute. These sizes are based on a drag coefficient of approximately 0.7 for the laid-out flat surface area.

3. Recoveries from inverted spins will be satisfactory by rapid rudder reversal and stick neutralization.

4. If necessary to abandon the airplane in a spin, the pilot should leave from the outboard side.

5 The rudder pedal force necessary to effect satisfactory recovery will be within the physical capability of the pilot.

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National Advisory Committee for Aeronautics
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TABLE I.- DIMENSIONAL CHARACTERISTICS OF THE NORTH AMERICAN XFJ-1 AIRPLANE

Length over all, feet	33.7
Normal weight, pounds	12,151
Normal center-of-gravity location percent M.A.C.	22.8
Wing:	
Span, feet	38.1
Area, square feet	255.3
Section	NACA 64_1-112, a = 0.6
Incidence:	
Root, degrees	1
Tip, degrees	-1.5
Dihedral, degrees	5
Aspect ratio	5.7
Mean aerodynamic chord, inches	84.3
Ailerons:	
Span, percent of b/2	36.6
Hinge line to trailing edge, percent of wing chord	25.0
Horizontal tail surfaces:	
Total area, square feet	59.7
Span, feet	17.6
Elevator area aft of hinge line, square feet	15.5
Distance from normal center of gravity to elevator hinge line, feet	17.9
Dihedral, degrees	10
Incidence, degrees	-.5
Vertical tail surfaces:	
Total area, square feet	30.2
Total rudder area aft of hinge line, square feet	7.3
Distance from normal center of gravity to rudder hinge line, feet	16.6
Tail-damping power factor	708×10^{-6}

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TABLE II.- CONDITIONS OF THE $\frac{1}{25}$-SCALE MODEL OF NORTH AMERICAN XFJ-1 AIRPLANE INVESTIGATED IN THE 20-FOOT FREE-SPINNING TUNNEL

[Landing gear retracted, flaps neutral, cockpit closed, right erect spins]

No.	Condition	Spin recovery parachute	Figure	Data presented on	
				Chart	Table
1	Normal	None	1,2	1	
2	Diving	--------------	3	2	
3	Long range	--------------	2	3	
4	Normal	Wing	------		IV
5	Normal	Tail	------		IV

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TABLE III.- MASS CHARACTERISTICS AND INERTIA PARAMETERS FOR LOADINGS OF THE NORTH AMERICAN XFJ-1 AIRPLANE AND FOR THE LOADINGS TESTED ON THE $\frac{1}{25}$-SCALE MODEL

[Model values converted to corresponding full-scale values; moments of inertia are given about the center of gravity]

No.	Loading	Weight (lb)	μ 15,000	μ sea level	Center-of-gravity location		Moments of inertia about center of gravity			Inertia parameters		
					$x/\bar{c}$	$z/\bar{c}$	I_X (slug-ft^2)	I_Y (slug-ft^2)	I_Z (slug-ft^2)	$\frac{I_X - I_Y}{mb^2}$	$\frac{I_Y - I_Z}{mb^2}$	$\frac{I_Z - I_X}{mb^2}$
Airplane values												
1	Normal	12,151	26.0	16.3	0.228	0.132	6,231	13,163	18,540	-127×10^{-4}	-98×10^{-4}	225×10^{-4}
2	Long range	14,402	28.6	18.0	.232	.117	32,224	13,359	44,664	251	-417	166
Model values												
1	Normal	11,952	25.5	16.0	0.221	0.134	6,556	13,096	17,962	-121×10^{-4}	-90×10^{-4}	211×10^{-4}
2	Long range	14,340	28.4	17.9	.235	.125	33,368	13,839	45,085	261	-417	156

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TABLE IV.- SPIN-RECOVERY PARACHUTE DATA OBTAINED WITH

THE $\frac{1}{25}$-SCALE MODEL OF THE NORTH AMERICAN XFJ-1 AIRPLANE

[Normal loading; rudder full with the spin; right erect spins]

Parachute diameter full scale (ft)	Parachute drag coefficient	Towline length full scale (ft)	Ailerons	Elevator	Turns for recovery
		Tail parachutes			
10.4	0.55	25	Neutral	Up	$\frac{1}{2}$, $\frac{1}{2}$
8.3	.67	25	Neutral	Up	$\frac{1}{2}$, 1, 1
8.3	.67	25	Against	Neutral	$\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$
7.3	.72	25	Neutral	Up	$1\frac{1}{4}$, $> 1\frac{1}{2}$, > 2
5.8	Approx. .70	25	Neutral	Up	1, $1\frac{1}{2}$, > 2
		Wing-tip parachutes			
4.2	0.74	11.4	Against	Neutral	$\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$
4.2	.74	11.4	Neutral	Up	$\frac{1}{2}$, 1, 1
2.1	Approx. .70	14.0	Neutral	Up	$> 1\frac{1}{2}$, > 2, > 3

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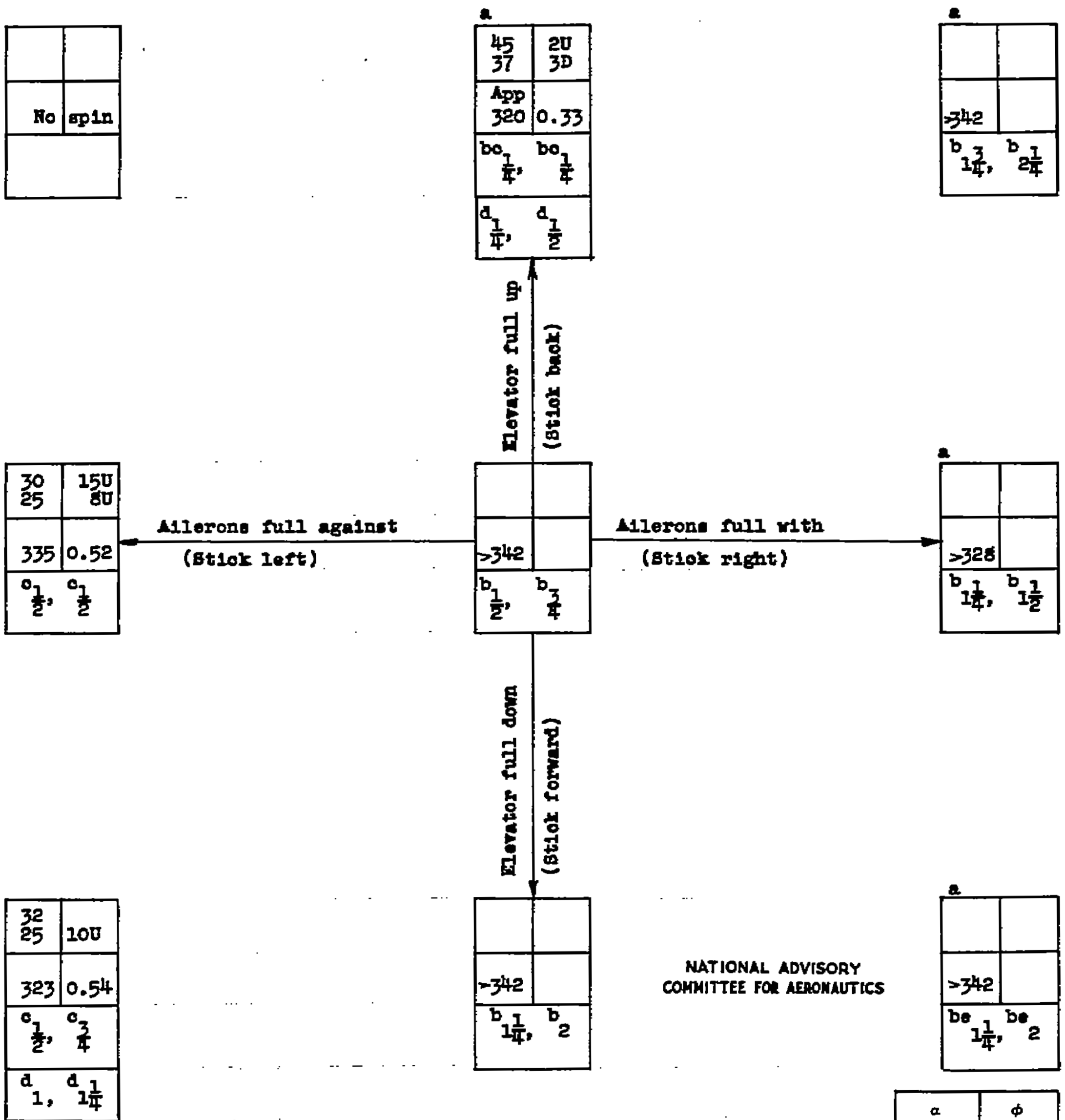
CHART 1.- SPIN AND RECOVERY CHARACTERISTICS OF THE $\frac{1}{25}$-SCALE MODEL OF THE NORTH AMERICAN XFJ-1 AIRPLANE IN THE NORMAL LOADING

[Flaps neutral; landing gear retracted; dive brakes retracted; cockpit closed; recovery attempted by rapid full rudder reversal except as indicated (recovery attempted from, and steady-spin data presented for, rudder-full-with spins); right erect spins]



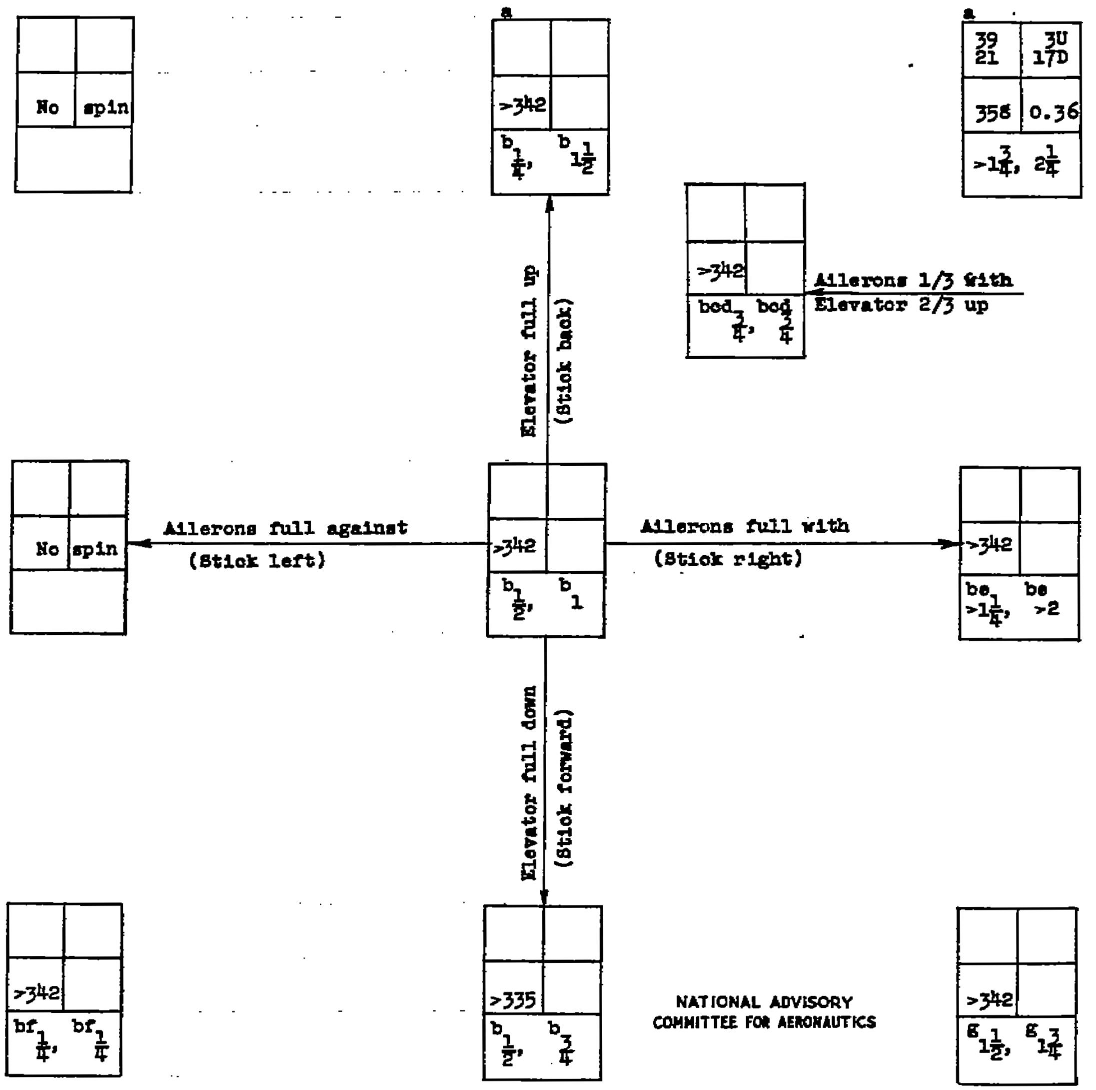
[a]Wandering spin.
[b]Recovery was attempted before model reached final steep attitude.
[c]After recovery, model entered spin in opposite direction.
[d]Recovery attempted by neutralizing rudder.
[e]Model goes into inverted spin after recovery.

Model values converted to corresponding full-scale values.
U inner wing up
D inner wing down

α (deg)	φ (deg)
V (fps)	Ω (rps)
Turns for recovery	

CHART 2.- SPIN AND RECOVERY CHARACTERISTICS OF THE $\frac{1}{25}$-SCALE MODEL OF THE NORTH AMERICAN XFJ-1 AIRPLANE WITH THE DIVE BRAKES FULLY EXTENDED

[Normal loading; flaps neutral; landing gear retracted; cockpit closed; recovery attempted by rapid full rudder reversal except as indicated (recovery attempted from, and steady-spin data presented for, rudder-full-with spins); right erect spins]



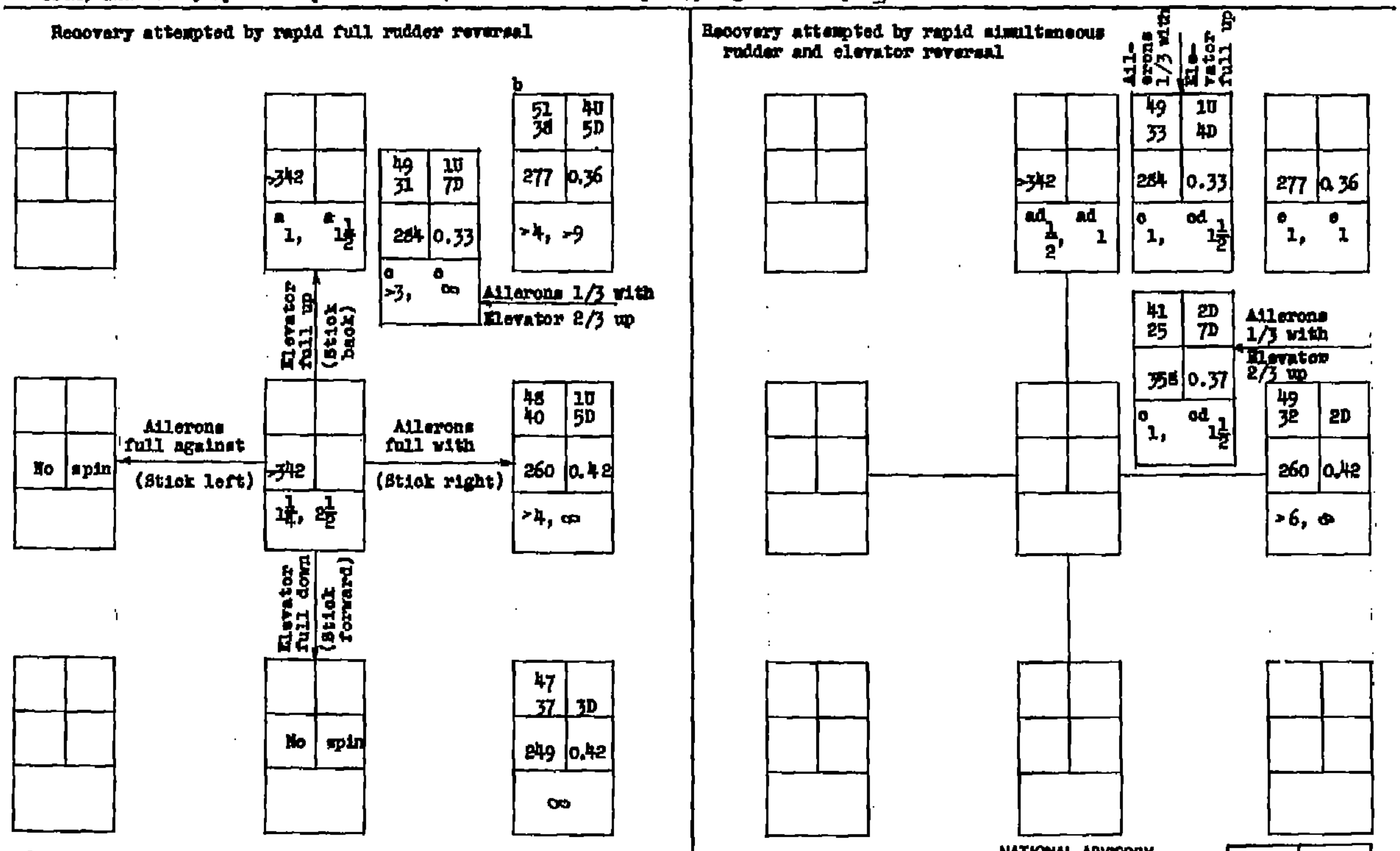
[a]Wandering spin.
[b]Recovery attempted before model reached final steep attitude.
[c]Recovery attempted by reversing rudder from full with the spin to 2/3 against.
[d]Recovers in wide radius glide.
[e]Goes into very steep attitude, on verge of recovery.
[f]After recovery, model starts to spin in opposite direction.
[g]After recovery goes into inverted spin.

Model values converted to corresponding full-scale values.
U inner wing up
D inner wing down

α (deg)	φ (deg)
V (fps)	Ω (rps)
Turns for recovery	

CHART 3.– SPIN AND RECOVERY CHARACTERISTICS OF THE $\frac{1}{25}$-SCALE MODEL OF THE NORTH AMERICAN XFJ-1 AIRPLANE IN THE LONG-RANGE LOADING

[Flaps neutral; landing gear retracted; dive brakes retracted; cockpit closed; recovery attempted as noted (recovery attempted from, and steady-spin data presented for, rudder-full-with spins); right erect spins]



[a]Recovery attempted before model reached final steep attitude.
[b]Very wandering, slightly oscillatory in roll and yaw.
[c]Recovery attempted by reversing the rudder from full with to 2/3 against the spin.
[d]Visual estimate.
[e]Model recovers then goes into an inverted spin.

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Model values converted to corresponding full-scale values.
U inner wing up
D inner wing down

α (deg)	ϕ (deg)
V (fps)	Ω (rps)
Turns for recovery	

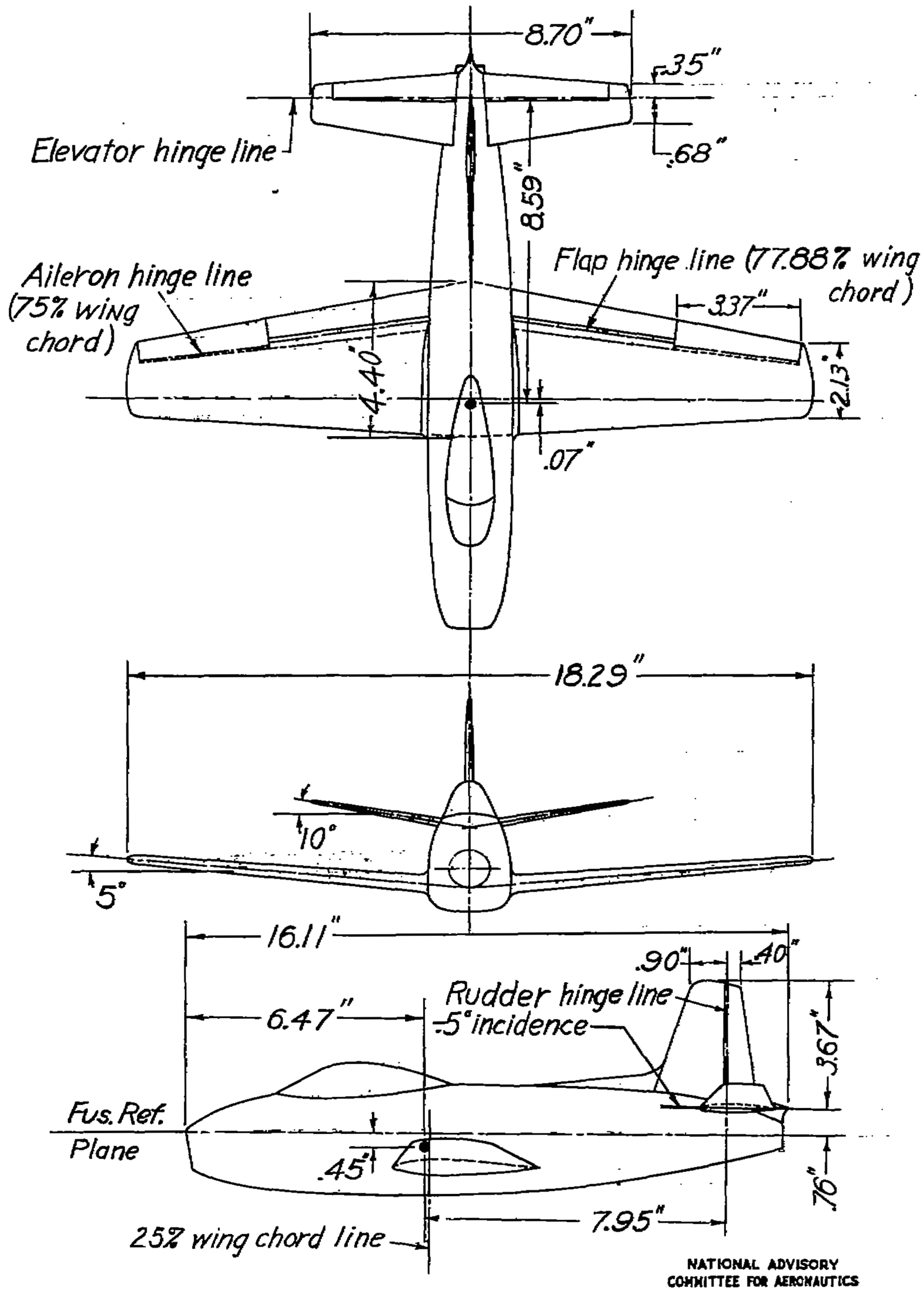
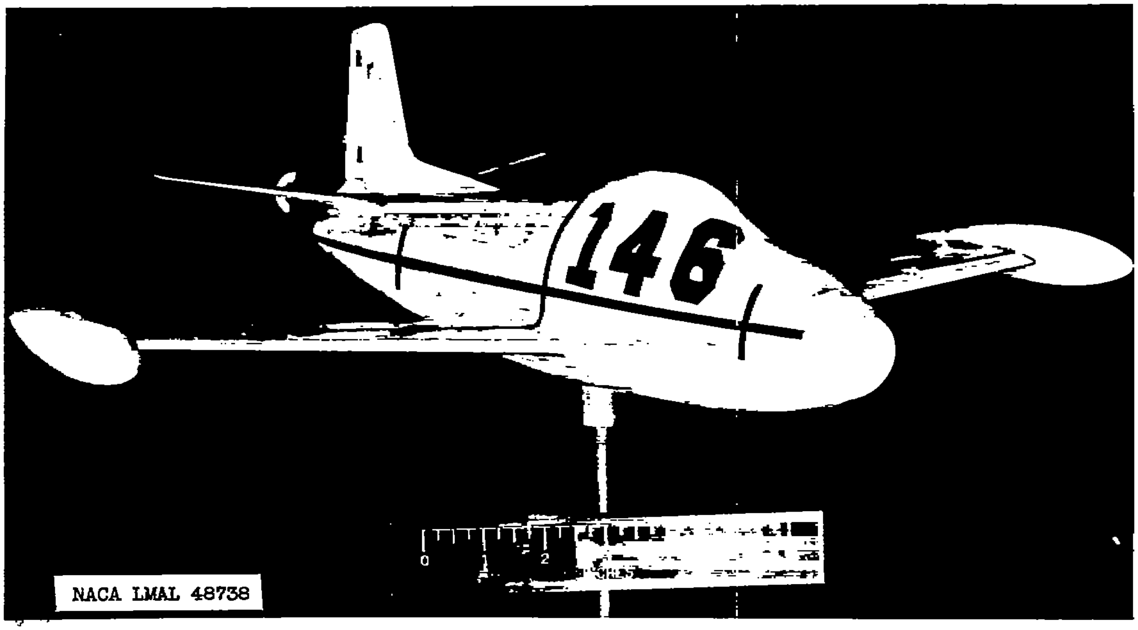
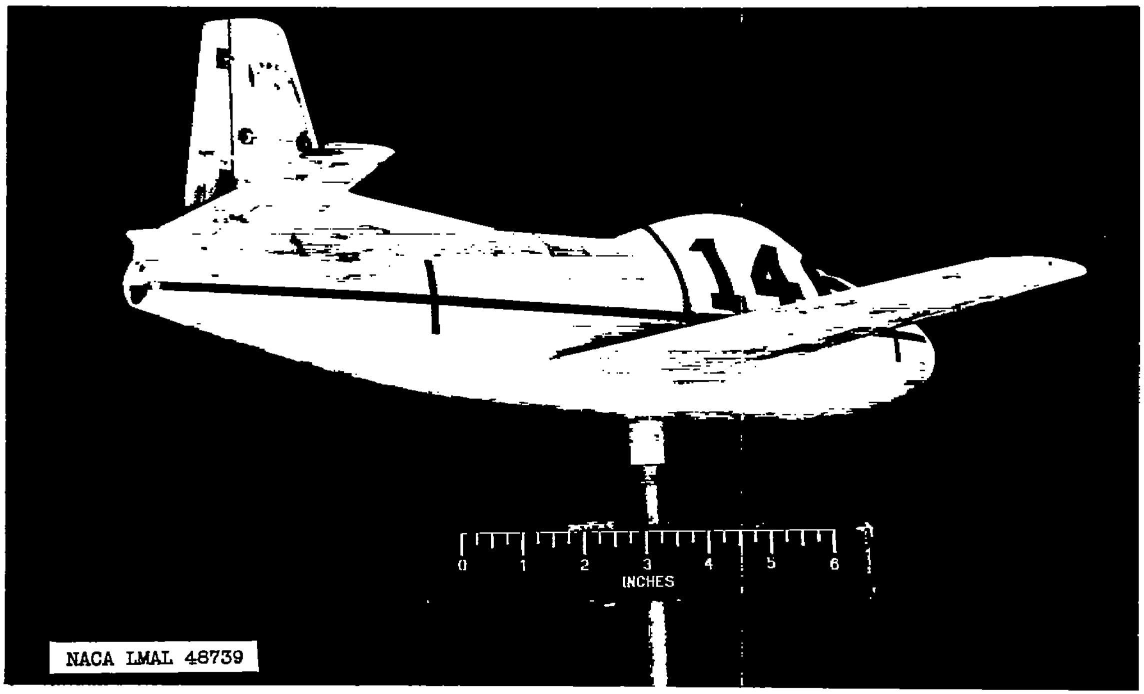


Figure 1.- Three view drawing of the 1/25-scale model of the North American XFJ-1 airplane as tested in the Langley 20-foot free-spinning tunnel. Center-of-gravity position is for the normal loading. Dimensions are model values.



(a) Long-Range Loading.



(b) Normal Loading.

Figure 2.- Photographs of the $\frac{1}{25}$-scale model of the North American XFJ-1 airplane in the long-range and normal loadings.

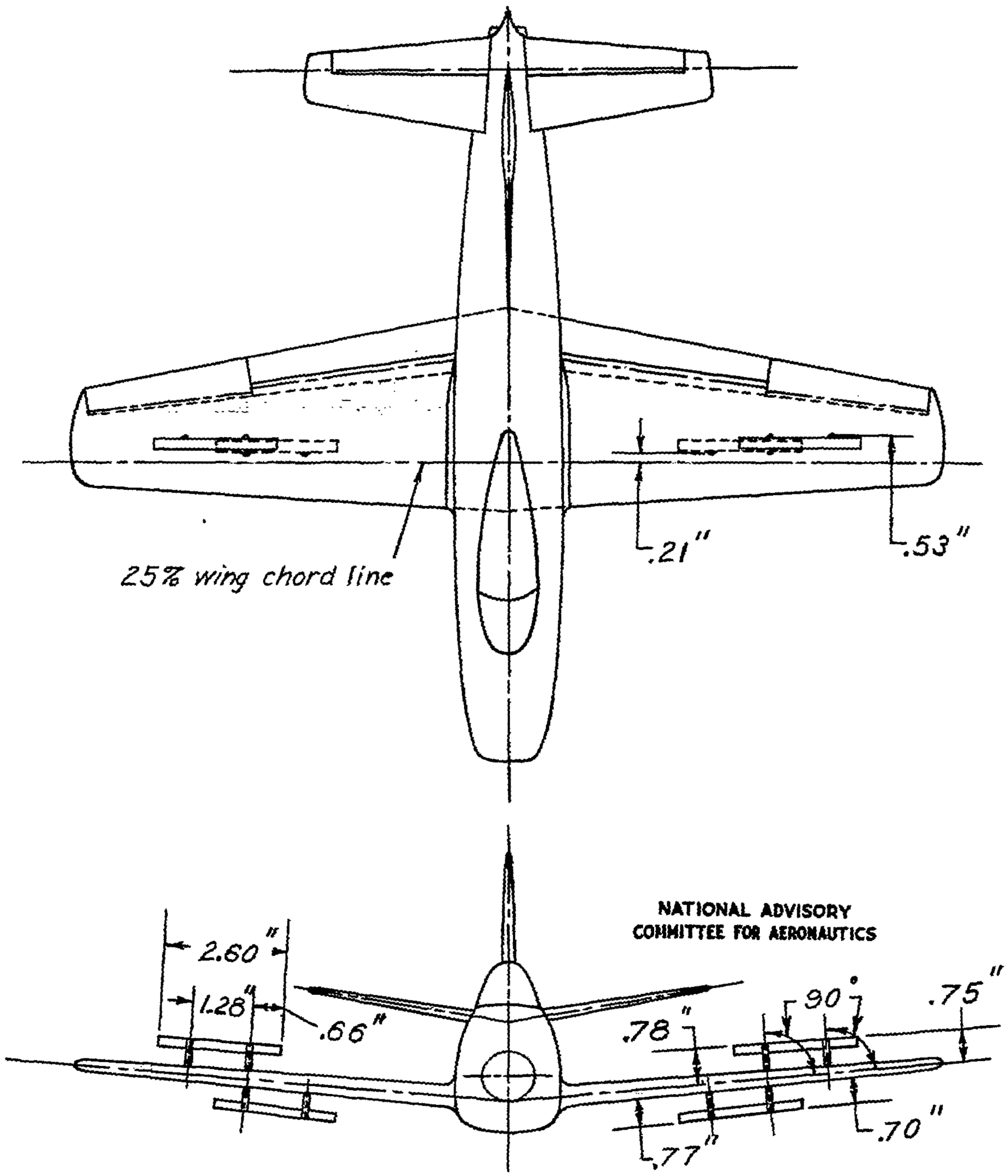


Fig. 3. Dive brakes extended as tested on the $\frac{1}{25}$-scale model of the North American XFJ-1 airplane. (Dimensions are model scale)

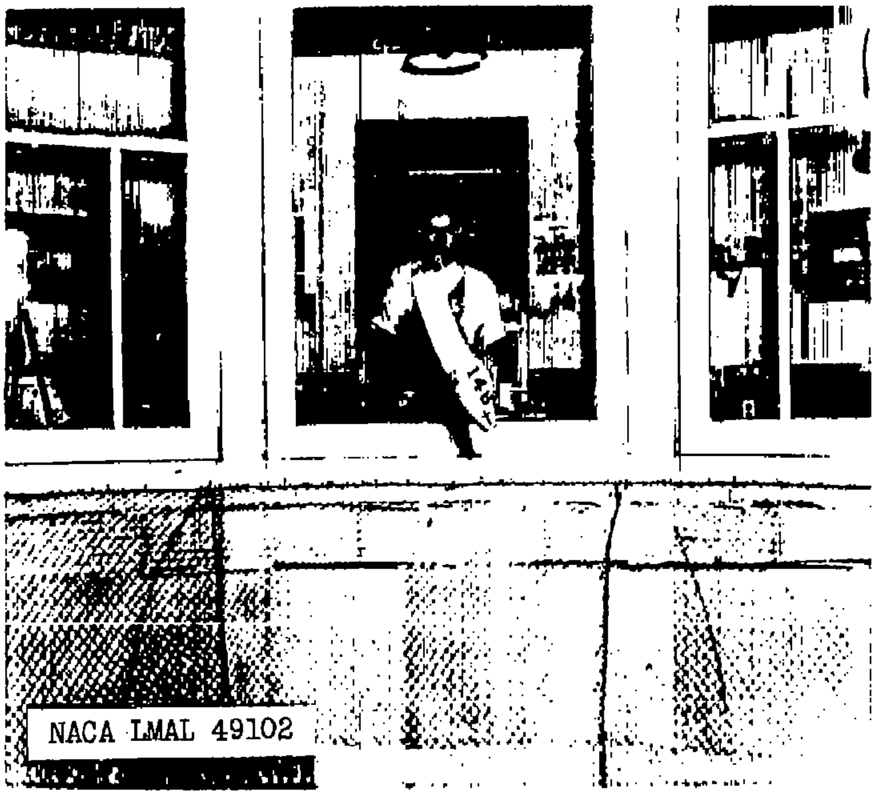


Figure 4.- Photograph of the $\frac{1}{25}$-scale model of the North American XFJ-1 airplane spinning in the 20-foot free-spinning tunnel.

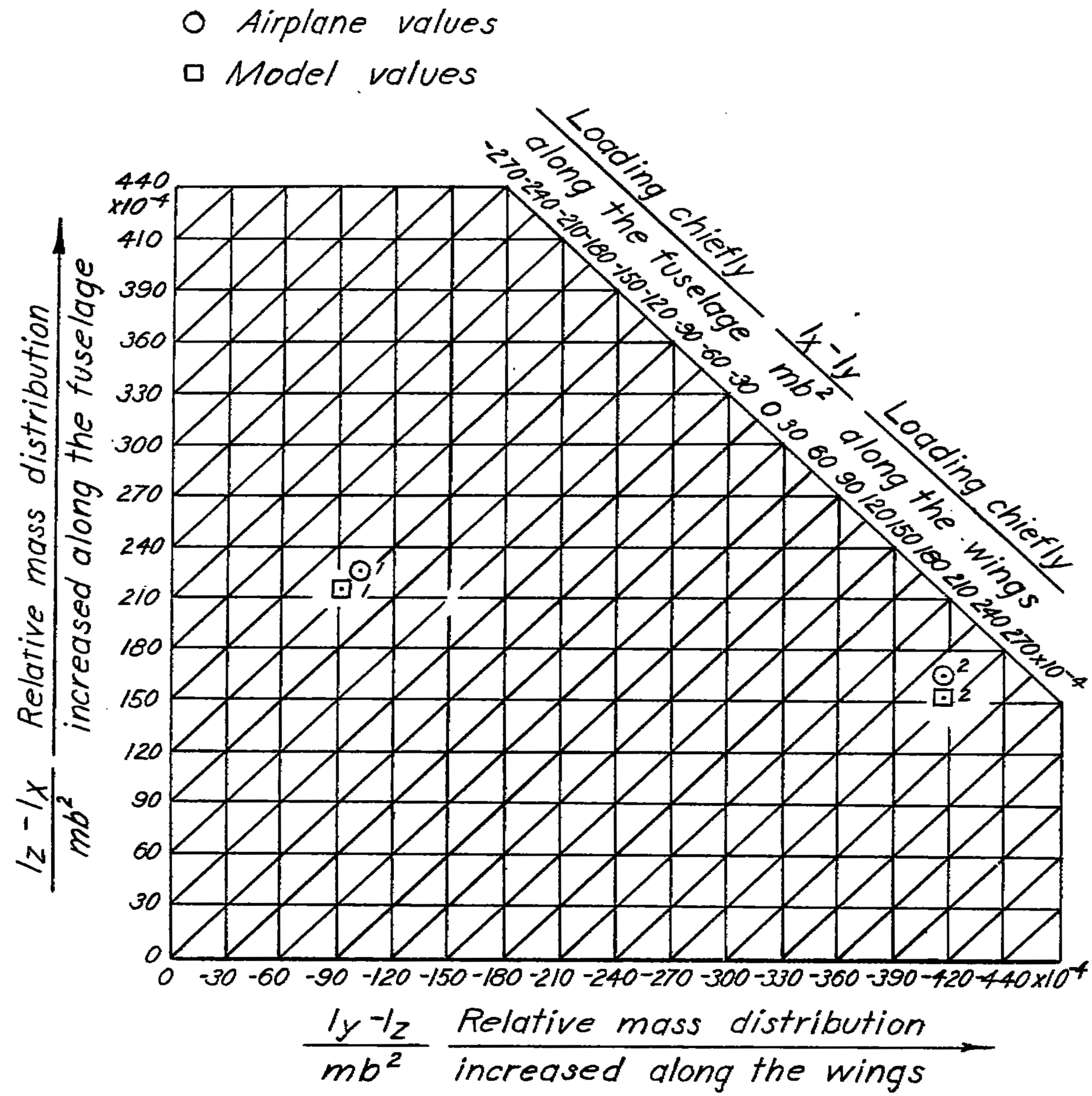


Figure 5. Inertia parameters for loadings of the XFJ-1 airplane and for the loadings tested on the model. (Points are for loadings listed on table III).

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